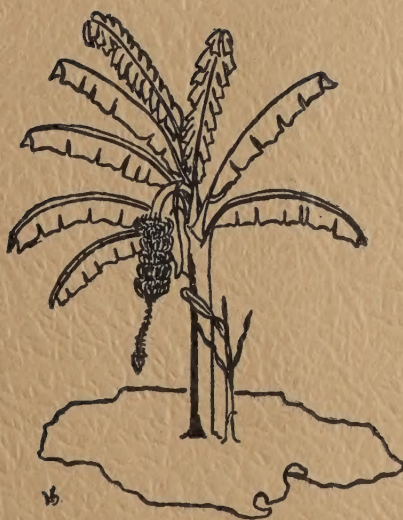


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BANANA BOARD RESEARCH DEPARTMENT

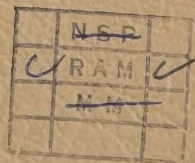
JAMAICA

ANNUAL REPORT

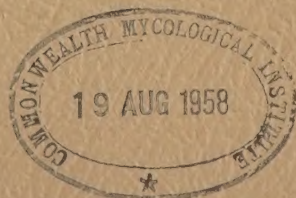
1956-1957



10 SOUTH AVENUE, KINGSTON GARDENS
KINGSTON, JAMAICA.



March, 1958



BANANA BOARD RESEARCH DEPARTMENT

"Fontabelle",
10 South Avenue,
Kingston Gardens,
Kingston, Jamaica, BWI.
21st January, 1958.

The Chairman,
Banana Board.
Dear Sir,

The Research Committee of the Banana Board have pleasure in submitting the first Annual Report of the Research Department covering 1st October, 1955 to 31st March, 1957. Subsequent Annual Reports will be in respect of the same period as that of the Banana Board's financial year.

Yours faithfully,

(SGD.) R. Leach,
Chairman of the Banana Board Research Committee
& Director of Research.

BANANA BOARD RESEARCH DEPARTMENT
ANNUAL REPORT

1956/1957.

INDEX

I. ESTABLISHMENT OF BANANA BOARD RESEARCH	
DEPARTMENT	p. 3
II. REPORT OF CROP PHYSIOLOGIST (E. A. TAI)	p. 3
(A) Fertilizer Trials	p. 4
(B) Timing of Production	p. 5
(C) Openhandedness	p. 5
(D) Premature Yellowing	p. 6
(E) Empirical Studies of The Banana	p. 7
(F) Plans For The Future	p. 8
III. REPORT OF SOIL CHEMIST (C. G. JORDINE)	p. 8
(A) Fertilizer Comparison Trials	p. 9
(B) Soil Studies At Bernard Lodge	p. 9
IV. REPORT OF AGRONOMIST (V. R. LUMSDEN)	p. 9
(A) Fertilizer Investigations	p. 9
(B) Time Of Planting	p. 10
(C) Cover-cropping	p. 10
(D) Observations On Sucker Growth	p. 10
V. REPORT OF PLANT PATHOLOGIST (R. LEACH)	p. 10
(A) A.I.B.G.A. Bordeaux/Triton Spraying Trial	p. 10
(B) Oil Spraying Trials For Control Of Banana Leaf Spot	p. 11
(C) Diseases Of Shipped Fruit	p. 18

ANNUAL REPORT — 1955/1956

I. ESTABLISHMENT OF BANANA BOARD RESEARCH DEPARTMENT

The Research Department came into existence on October 1st, 1955. The staff was gradually assembled during the ensuing year so that by the end of 1956 the following divisions had been embodied:—

- (a) Chemistry and Crop Physiology
- (b) Agronomy
- (c) Plant Pathology

The work of the Department has been designed to cover a wide range of investigations, particularly directed towards two main issues, namely —

- (1) the best means of economically procuring the largest quantity of marketable count bunches of bananas per acre in the summer months of the year, as requested by the Board of Directors of the A.I.B.G.A.
- (2) the reduction of disease in the field and in fruit shipped overseas.

In view of the large number of soil types now recognised in Jamaica and the varied topography of the banana growing areas, no experimental research stations have been established by the Department. The policy is to spread the work throughout the island, relying on the co-operation of growers interested in the problems requiring investigation.

Orthodox fertilizer experiments have been designed more for the purpose of providing data to be available for the multiple correlation of soil analyses, foliage analyses, growth and yield records than for *ad hoc* investigations into the fertility requirements of local banana soil types. This constitutes a new line of approach to the study of the nutritional requirements of the banana plant in Jamaica and, in fact, elsewhere. A great deal of field recording has necessarily to be undertaken because most of the past work on bananas in Jamaica has been carried out on the Gros Michel variety which, owing to the ravages of Panama Disease, has largely been replaced by the Lacatan variety and, to a lesser extent, by the Robusta variety. The relative quantities of the two main varieties shipped in 1956 were:

Lacatan	9,867,630
Gros Michel	1,348,169

A field recording staff has been constituted to obtain detailed data from the island-wide investigations undertaken by the Technical Officers of the Department. Three Field Officers are stationed in the Western, Central and Eastern Areas of Jamaica under the direction of a Senior Field Officer. All work undertaken by the Field Officers is assigned to them only through the direction of the Senior Field Officer to whom all Technical Officers refer their field experimentation projects. In the Research Department the Field Officers therefore play an invaluable role and reports of their work are *ipso facto* included within those of the Technical Officers.

Owing to a series of unaccountable delays, the Research Department Laboratory was not completed by the end of 1956. The absence of a Laboratory has, in a way, been opportune because the Technical Officers have been forced to study the banana plant entirely in the field throughout the year. The gratitude of the Research Department is acknowledged here to all those growers who have provided facilities for field experimentation in their banana plantations.

The following reports of the year's work carried out by individual Technical Officers are submitted below.

II. REPORT OF CROP PHYSIOLOGIST (E. A. TAI)

The Crop Physiologist was appointed as from 1st January, 1956, and assumed duties shortly after. The main function of the Physiology section was defined as investigation of as many phases as possible of nutrition and growth of bananas with the object of increasing efficiency of production. Work in this connection had up to then been carried out by the Agricultural Department and by the All Island Banana Growers Association, and several experiments laid down by them were still in progress in different parts of the island. It was thought, however, that tangible results would more likely be achieved from concentrated efforts of a special section of the Research Department.

There was already in the Department a Chemist on secondment from the All Island Banana Growers Association, Mrs. S. F. Williams, who was assigned to this section as

Analyst and was later so appointed. A Soil Chemist-designate, Mr. C. G. Jordine, was at the time receiving special training at the Imperial College of Tropical Agriculture in Trinidad; he joined the section at the beginning of August. Recruiting of junior staff was given attention soon after the commencement of the 1956-57 financial year in April, and by the end of October all posts of Technical (Laboratory and Field) Assistants, four in number, were filled. The Analyst, Mrs. Williams, went on long leave on the 1st of September and was not due back until March 1957.

In the absence of a Laboratory, the Crop Physiology Section occupied an office at No. 5 Central Avenue, Kingston Gardens, together with the Agronomy and Field Experiments Sections. Such laboratory work as was undertaken prior to assumption of duty by the Soil Chemist was carried out for a fee by the Department of Agriculture; arrangements have since been made for the Soil Chemist to make use of equipment and space kindly provided free of cost by the Chemistry Division of the Department of Agriculture.

In view of the absence of adequate laboratory facilities it was deemed advisable by the Director of the Research Department to devote attention at the start to work in the field and to follow a system of priority according to the most pressing problems of the Banana Industry. A survey of experiments in progress was made in January and it was decided to persist with only those in which there had been a reasonably satisfactory continuity in application of experimental treatments and recording of observations; the others were discontinued and the records held for examination and analysis.

Before embarking on the programme of new experiments there was a special meeting held in February between the Director of Research and representatives of the All Island Banana Growers Association to discuss the most urgent needs of the Banana Industry. In keeping with the expressed objective of "obtaining the greatest number of marketable bunches per acre per annum to be harvested during the summer months of the year", it was decided that the Crop Physiology Section should undertake investigations into use of fertilizers, timing of main crop production, nature and cause of openhandedness in fruit, the cause and control of premature yellowing disease of bananas, and of empirical studies of the banana.

The Crop Physiology Section was chiefly concerned with these problems but it also collaborated with the Banana Agronomist of the Department of Agriculture in providing an advisory service to banana growers. The Banana Agronomist continued as the part-time member of the staff of the Banana Board Research Department until June 1956. In August, on the appointment of Mr. V. R. Lumsden to the post of Agronomist in the Department, arrangements were made to transfer responsibility for advice to growers and maintenance of a number of the fertilizer trials to the new Agronomy Section.

The principal activity in the advisory work consisted of the planning of fertilizer schedules for growers. Chemical analysis of the soil, together with consideration of the type, was used as the basis of advice. Collection of soil samples was done by the Crop Physiologist but the analyses were carried out by the Agricultural Chemistry Division of the Department of Agriculture. It is anticipated that future advisory work will rest with the Agronomy Section and analyses will be done by the Analyst of the Crop Physiology Section when the Banana Board Research Laboratories are completed.

A. Fertilizer Trials

The Crop Physiologist assisted in the planning and laying down of a new series of 3x3x3 NPK trials in a large number of banana growing areas, but has participated, to a limited extent only, in actual field operations. Ten complete experiments of three blocks each were laid down by the end of October. All blocks of any individual experiment were located on soil of the same type, but generally on separate holdings.

Investigations were undertaken to assess the economic value of several fertilizers which have gained popularity with banana growers and to compare a number of these under varying conditions of banana production. Records of costs, growth and yield data are being collected for subjection to statistical analysis in due course. The experiments which were laid down by the Crop Physiologist at Cherry Gardens and Bernard Lodge and the St. Catherine Plains, and Ballards Valley near Port Maria and Roseville near Richmond were handed over to the Agronomy Section in October and are covered in the report of the Agronomist.

In collaboration with the Research Departments at Bernard Lodge and Jamaica Sugar Estates, observations were commenced on varying the frequency of application of nitrogenous fertilizers. These observations were also handed over in October to the Agronomist.

B. Timing of Production

In keeping with the need for devising a system of management to induce maturing of the main crop of Lacatan banana during the summer months, experiments have been planned to attempt control of growth and fruiting and also to obtain information on the succession of crops resulting from existing management practices. As well, careful note is made of the rate at which successive crops are produced in all other experiments. The claim that it is practicable on the irrigated plains to obtain three crops in two years is being subjected to critical check.

Two simple pruning experiments were laid down during the year — one at Bernard Lodge in February and the other at Parnassus in September. At both locations the treatments have been applied to young plants as follows:—

- (a) Standard estate practice of selecting a follower based on Gros Michel experience.
- (b) Selection of the first sucker to emerge as follower.
- (c) Selection of a sucker which it is estimated should follow the parent at approximately a year.
- (d) No pruning of suckers until after the parent has shot at which time selection of the follower is made.
- (e) Pruning away all suckers as they appear until the parent has shot; after that the first sucker to emerge is selected as follower.

The first plants shot at Bernard Lodge in May but the bulk of the shooting occurred in July to September and reaping of the first crop was not quite completed at the end of the year although several of the ratoons had already shot.

C. Openhandedness

The very serious problem of openhandedness has been under active study since the beginning of the year. It is well known that openhandedness increases the difficulty of efficient handling, transport and storage of bananas because deflection of the fingers with attendant damage to the crowns is easy on openhanded fruit. As a direct consequence openhanded bananas are regarded as more prone to attack by Santa Marta stem end rot (Finger stalk rot).

(i) **Measurement of openhandedness:** An arbitrary method of measuring openhandedness was devised in January and is now in use in all experiments. Four degrees of openhandedness are recognised:

- 0 — compact, fruit no hands open
- 1 — single hand open
- 2 — more than one hand open, but not more than two on the same side of the stem
- 3 — more than two hands open on the same side of the stem.

The degree of openhandedness is recorded for fruit harvested from nearly all experiments carried out by the Research Department with a view to obtaining as much information as possible on the natural circumstances attending occurrence of the condition.

(ii) **Influence of environment:** The greatest outbreak of openhandedness was observed on the irrigated alluvial plains of Vere and southern St. Catherine during the early months of the year and it has been claimed that its occurrence is seasonal and may be expected each winter. Assessment of the amount of openhandedness encountered in the fruit harvested from selected locations each week was started in March and is planned to continue for at least a complete calendar year. As many as are available of the meteorological records for the same locations will be obtained to determine, if possible, the influence of climate on openhandedness. From the records already compiled there appears to be an indication that fruit which developed during a very dry period exhibit a higher degree of openhandedness than fruit developing during a period of medium to heavy rainfall.

(iii) **Field trials:** It is obvious that the open-ness between the hands on a stem must be due to the failure of the fingers to grow sufficiently to fill the gaps between the crowns on which successive hands are borne. In a limited number of measurements made by the Crop Physiologist on developing stems of banana, it was observed that the inter-crown distances apparently ceased to elongate appreciably after shedding of the proximal bract while the fingers continued to increase in length until they had completed the upward curvature, between ten and fourteen days after they became exposed. It seems probable, then, that the occurrence of openhandedness in the fruit at harvest may be a function of growth rates in the plant at certain stages of its development.

Three experiments to explore this were laid down at Monymusk with application of treatments calculated to affect growth rates.

A. Root pruning: In a field which produced a high percentage of openhanded fruit it was arranged to root-prune by means of a subsoiler at different times of the year,

- | | |
|--------------|----------------------------------|
| (a) February | — dormant season |
| (b) April | — spring, start of active growth |
| (c) July | — summer, most active growth |
| (d) October | — fall, declining growth |

a number of rows of first ratoon bananas and to assess openhandedness of fruit produced by marked individuals which, at the time of sub-soiling were estimated to be

- (1) Full grown just after shooting
- (2) Three-quarters grown
- (3) Half-grown
- (4) One-quarter grown

It was also arranged to carry out measurements of growth of each marked plant from application of the treatment until harvest of the fruit.

A simple lay-out with a control plot adjoining each treated plot was adopted as the most easily practicable and by the end of October all the treatments were applied. Observations and recordings are not expected to be completed before March 1957.

B. Fertilizer treatment: Possible effects of modifying growth rates at different stages of plant development by manipulation of the fertilizer schedule are under investigation in a field of banana planted in October 1955. All plants of the experiment received the same total amount of sulphate of ammonia, the only fertilizer applied, with instalments identical up to four months but thereafter varied to give, as near as possible, the following experimental treatments:

- (a) Control — balance for the year in eight equal instalments.
- (b) No fertilizer between four months and "bulling", the balance in equal instalments for the remainder of the year.
- (c) No fertilizing between "bulling" and completion of the pistillate stage of the inflorescence, regular fertilizing otherwise to ensure the same total application for the year as other treatments.
- (d) Balance of fertilizer in increased instalments to ensure application of the total annual dressing just prior to "bulling", estimated at the 10th month from planting.

The first year's application of fertilizers has been completed and reaping of fruit is well under way in the experimental area which consists of five randomised blocks with 6 stools to each plot.

C. Heredity versus environment: An experiment in two parts was laid down at Monymusk in April to observe the effects of field conditions and source of planting material on openhandedness of the fruit produced. One part of the experiment is in a field immediately adjacent to another in which the incidence in the plant crop is very high; the other part is in an area in which bananas in neighbouring fields show little openhandedness. In both parts of the experiment were planted equal numbers of suckers from

- (a) Parent plants known to have yielded openhanded fruit in a field where the general incidence of openhandedness is high.
- (b) Parents known to have produced average compact fruit in a field from which few openhanded stems were reaped.

Measurements of growth are being carried out on individual plants for correlation with extent of openhandedness when the experiments are reaped.

D. Premature Yellowing

The banana disorder which was first reported at Woodstock in Portland in 1953 has since been attracting considerable attention. Its occurrence, which is frequently associated with conditions of low soil potash and often also with unsatisfactory moisture relations, has been observed in the banana growing areas of Portland, St. Thomas, St. Catherine, Clarendon, St. James, Hanover and Westmoreland.

Several "shot-gun" trials have been laid down to explore a possibility of correcting the condition by simple field treatments. It is felt, however, that detailed physiological and

chemical investigations, which will only become possible after establishment of our laboratories, are more likely to yield reliable results.

A. Little Spring Garden — Portland. Injections of .01 M solutions of Potassium dihydrogen phosphate
Potassium nitrate and
Di-ammonium hydrogen phosphate

in 50 ml amounts were made into a number of young plants showing symptoms of premature yellowing. The first injections were made in June and the treatment repeated on some of the plants in August. Records of the yellowing of leaves on individual plants show no appreciable differences although from visual observations a number of those plants injected with potassium nitrate appeared slightly more vigorous than the controls at the end of the year. The soil on which the plants are growing is a light, sandy alluvium of low potash status.

B. Jamaica Sugar Estates — St. Thomas. Soil applications of conventional fertilizer materials and trace element mixtures are being tried as well as injections. Two experiments were laid down for observation of the malady. In one of these single applications of

- (a) Super-phosphate and muriate of potash — approximately 2 lbs. of a 1-1 mixture to a root.
 - (b) Filter press mud — 16 tons per acre.
 - (c) Kieserite — 1 lb. per root.
 - (d) Ferro Rexenol Granulate (Iron chelate) — $\frac{1}{8}$ lb. per root.
 - (e) Sporumix B (a proprietary mixture containing trace elements) — $\frac{1}{8}$ lb. per root
- were made, in addition to routine fertilizing with sulphate of ammonia on a silty clay, alluvial soil which had previously given good yield of sugar cane with nitrogen fertilizers alone. The plant crop of bananas was lost completely from the effects of premature yellowing and treatments were applied to the first ratoons, in June. Before December when observations were concluded there was appreciable improvement in the appearance of all plots of the trials including the controls. There was insufficient evidence for conclusion to be drawn, but it appeared that the treatments involving application of magnesium as Kieserite or Sporumix B showed more readily discernible effects and in a shorter time than the others.

In the other experiment the bananas were second ratoons after failure of plants and first ratoons. Here treatments which were commenced in August included

- (1) Injections as at Little Spring Garden
- (2) Soil applications of
 - (a) Urea — $\frac{1}{4}$ lb. per root
 - (b) Albatros 12:15:18 — $\frac{1}{4}$ lb. per root
 - (c) Kieserite — $\frac{1}{2}$ lb. per root
 - (d) Ferro Rexenol Granulate — $\frac{1}{4}$ lb. per root
 - (e) Sporumix B — $\frac{1}{4}$ lb. per root

with (a) and (b) three times a year and the others once only. No remarkable effects of treatments have yet been observed.

C. Retirement — St. James. Injections with .02 M solutions of the chemicals used at Little Spring Garden and Jamaica Sugar Estates were applied in September to first ratoons after premature yellowing had caused considerable loss in the plant crop. There have not yet been observed any differences.

D. Spring Garden — Westmoreland. Recording of premature yellowing is being done on plants of 3x3x3 NPK Fertilizer Trials. As well, applications of (a) Sporumix B, (b) Ferro Rexenol Granulate, (c) Kieserite, have been made to small observation plots in a field where premature yellowing appeared in September after a prolonged wet period on plants fertilized with A.I.B.G.A. Mixture C.

In an adjoining field fertilized only with sulphate of ammonia in 1955, very severe losses were experienced from the malady. It has been observed that a greater amount of yellowing occurs on the plots which do not receive potash.

E. Empirical Studies Of The Banana

It is recognised that sound fundamental knowledge of the anatomy and physiology of the Lacatan banana plant will be of the greatest importance in evolving cultural and management techniques for improving the efficiency of production. Empirical observa-

tions are, therefore, in progress on different aspects of growth and development. It is planned to devote an increased amount of time to this phase of the work when improved facilities are available.

(i) **Root Studies:** Examination of soil cores taken from banana fields was commenced in January but was discontinued to be resumed at a later date. The technique of serial profile examinations as has been used by Summerville in Australia was also employed for examination of banana root development at Bodles, Jamaica Sugar Estates, and Spring Gardens. The preliminary observations made to date seem to indicate that the majority of the roots of the Lacatan banana occur in the first foot of soil and that they rarely extend beyond three feet from the main stem, although roots were on occasions traced over 8 ft.

(ii) **Pot Culture:** Observations on growth of shoot and root of a Lacatan banana plant set in May in a box 6'x3'x3' with one side of plate glass are in progress. The soil is silty clay loam topsoil of the Liguanea Plain and no fertilizer has been applied; water is added as required to supplement natural rainfall.

Measurements of leaves and those roots which are visible through the glass indicated that rapid growth continued without a break until September, then slowed down and almost completely stopped; elongation of the roots ceased and unfurling of leaves became extremely slow. At the same time peepers appeared — three between 22nd October and 2nd November — and although these developed steadily their rate of increase in height was slow, the tallest being 15 inches and the smallest just over 2 inches above the soil level at the end of the year.

(iii) **Time of Planting:** At Bodles, Old Harbour, on the Banana Breeding Station, planting of a series of monthly plots of 12 stools each was commenced in May. Measurements of height increases and leaf production have been made at regular intervals and individual plants are dissected from each plot, commencing three months after planting to observe morphological changes with age. The Agronomist has collaborated in this project and we have been fortunate enough to secure valued help from the Botany Department of the University College of the West Indies.

Observations made show that buds which grow into suckers tend to elongate a group at a time rather than one after another, and the growing point of the main plants remains at approximately ground level until formation of inflorescence initials. The first flower primordia were seen in November in five-month old plants from the May plot. One month later over 50% of the original plants in the same plot had "bulled" indicating that progress of the inflorescence from ground level to the top of the plant must be rapid, a distance of about 96 inches in a month! Flower primordia were also seen in the June plants at 5 months in December.

E. Plans For The Future

It is anticipated that the laboratories will be completed early in 1957, then extension of the present programme of the Crop Physiology Section will be possible. Current projects are to be continued and additional ones initiated in keeping with the increase in working facilities.

The Crop Physiologist will undertake further studies on the growth of the banana plant especially in connexion with pruning and crop succession, treatment of openhandedness, premature yellowing and some biochemical aspects of banana nutrition with the collaboration of the Analyst who is to superintend the work of the chemical laboratories and be responsible for routine soil and plant tissue analyses. The Soil Chemist will be engaged on a critical survey of soils on which bananas are grown and assist with a number of fertilizer trials.

III. REPORT OF SOIL CHEMIST (C. G. JORDINE):

The Soil Chemist began work with the Banana Board Research Department on 3rd of August, 1956.

At first he familiarised himself with the organisation of the Banana Industry and with the work of the Banana Board Research Department. The experiments in progress were studied and visits were made to a number of the experimental areas. A preliminary study was made of the principal soil types in the parish of St. James, with particular reference to those on which bananas were growing, in the course of a week spent with one of the members of the Soil Survey Team.

The absence of laboratory facilities handicapped much of the work which should have

been done. The Head of the Agricultural Chemistry Division of the Agricultural Department at the Government Laboratories at Hope kindly gave permission for some soil analyses to be carried out, free of cost to the Banana Board. Needless to say, the Banana Board Research Department has been very grateful for this help, which has enabled chemical and mechanical analyses to be made on over fifty soil samples. Preparations have been made to initiate soil testing when the laboratory is opened.

A. Fertiliser Comparison Trials

These have been initiated by the Crop Physiology Section with a view to comparing certain commercial compound fertilisers (which have gained popularity with banana growers) with regard to their value in economic banana production.

One was laid down at Little Spring Garden, St. Margaret's Bay. Here certain commercial compound fertilizers e.g. Granumix C, and some compound fertilizers containing nitrogen in the form of urea are being compared with A.I.B.G.A. Mixture C as a complete fertilizer on the sandy soils of that area in Portland. The layout is a randomised block design with 6 replications involving the following treatments:

(a) Mixture C (A.I.B.G.A.)	at 24	ozs/root/year		
(b) Granumix C	" 24	" "	" "	" "
(c) Albatros	" 16	" "	" "	" "
(d) NPK mixture with urea as the source of nitrogen	" 22¼	" "	" "	" "
(e) NPK mixture with urea as the source of nitrogen	" 17½	" "	" "	" "

The fertilizers are applied in three times each year — October, April and July.

B. Soil Studies At Bernard Lodge

There are cases in banana cultivations where fields, though planted at the same time, and treated similarly, differ greatly in time taken to bear and also in their productivity. One poor field on the St. Catherine Plains yielded 2.7 count bunches/acre from period August 1955 (i.e. date of planting) to 13th October, 1956, whereas another nearby field yielded 183.2 count bunches/acre over the same period. Chemical analyses including sodium chloride (NaCl) content are being conducted on soil samples from each field. The physical determinations include mechanical analysis, field capacity, and also monthly determinations of total pore space down the soil profile. These, it is hoped, will give an indication of the reason for the great difference in productivity between both fields and constitute a start in an attempt to discover the factors which make up productive and non-productive banana soils especially in those which in many cases appear very similar macroscopically.

IV. REPORT OF AGRONOMIST (V. R. LUMSDEN):

The Agronomist began work with the Banana Board Research Department on the 20th August, 1956. Most of his time has been spent in making himself familiar with the various banana growing areas in Jamaica. A large number of experiments, initiated by other workers have been handed over to him, these being nearly all concerned with fertilizer problems. These experiments were reorganised before any new ones were considered.

The following programme of work has been undertaken:

A. Fertilizer Investigations

(i) **Comparisons:** Urea is being compared with sulphate of ammonia both at monthly and quarterly applications. A sub-treatment imposed on the experiment consists of fertilizer left on the surface as opposed to fertilizer dug in.

Sources of N in complete fertilizer, urea and sulphate of ammonia are being used as a comparison with Humber Fish Manure. Urea is being tested as a source of nitrogen compared with sulphate of ammonia and Humber Fish.

Humber Fish, Albatros, NPK/urea, and NPK/sulphate of ammonia are being tested on an equal nutrient basis.

Humber Fish, NPK/sulphate of ammonia, NPK/urea, Granumix C and A.I.B.G.A. Mixture C are being compared.

(ii) **Frequency:** Monthly, bi-monthly and quarterly applications of fertilizers are being applied at three different levels of N, at the same time urea is being tested against sulphate of ammonia as the source of N. Levels of fertilizer — N₀, N₁, N₂.

(iii) **NPK trials:** There are thirteen complete 3x3x3 factorial experiments scattered over the island on different soil types. In addition there are 10 old trials laid down by Mr. T. O. Ellis which will be continued for one more crop.

B. Time of Planting

At Bodles planting is being carried out every month and dissections of the plants are being made to determine the time of inflorescence initiation.

C. Cover-cropping

An experiment laid down by Mr. R. E. Osborne, Chief Agricultural Officer, Crop Agronomy Division of the Department of Agriculture, when he was seconded to the A.I.B.G.A., consists of testing various cover-crop treatments on an irrigated soil. The object of this experiment is to compare various covers such as Canavallia, bagasse and weeds with clean cultivation.

D. Observations On Sucker Growth

Suckers have been marked at different times of the year at various altitudes throughout the banana growing areas in order to obtain some idea of the time taken for followers to "shoot" at these various altitudes and under varying types of cultivation.

V. REPORT OF PLANT PATHOLOGIST (R. LEACH):

A. All Island Banana Growers Association Bordeaux/Triton Spraying Trial

H. G. H. Kearns and A. G. Naylor⁽¹⁾ proved the value of wetting agents added to fungicides used to control the type of Leaf Spot (tip spotting) caused by the ascospore stage of *Mycosphaerella musicola*.

The wetting agent, Triton X-114, has been used in Central America for Bordeaux spraying against the conidial stage but, as far as was known at that time, it had not been tried where ascospore infection was predominant. Naylor later found that Triton X-114 was a more suitable wetting agent for use in Bordeaux mixture than all those previously tested by Kearns and himself.

During the course of an advisory visit paid in March, 1955, by the Plant Pathologist prior to his appointment to the Banana Board Research Department, a programme for an island wide trial of Bordeaux + Triton was planned for the All Island Banana Growers Association. The co-operation of twenty-two growers was obtained and each agreed to put

- (a) 10 acres of bananas under "comprehensive" Bordeaux + Triton spraying using 100-150 gallons per acre applied to all the foliage as in the usual estate practice. Three ounces of Triton were added to every 100 gallons of Bordeaux mixture
- (b) 10 acres under "three leaf" spraying with Bordeaux + Triton, applied to the lower surface of the three youngest open leaves using approximately 50 gallons of spray per acre. The ordinary estate spraying without Triton was used as a control.

The object of the three leaf spraying was to demonstrate the principle of concentrating the spray only on the lower surfaces of the youngest leaves and to test the possibility of reducing the quantity of Copper Sulphate and Lime applied in each spray cycle.

The growers concerned nearly all co-operated fully despite the fact that three leaf spraying was more exacting than the normal, comprehensive spraying due to the time taken in seeking out the individual young leaves. As soon as the Research Department was established, the results of these trials had to be assessed at the request of the A.I.B.G.A.

There was a significant difference between Bordeaux mixture used with and without the addition of Triton. The absence of any difference between the three leaf and comprehensive Bordeaux/Triton treatments confirmed the principle of concentrating the spray on the youngest leaves of the plants. There was a considerable difference between the standard of control obtained on different estates, as shown in the Table, but three leaf spraying only failed to maintain control at a high standard on those estates where comprehensive spraying did likewise.

Acting on knowledge gained from previous experience (Leach⁽²⁾), it was decided to assess the value of the different spray treatments by recording the amount of spotting on the seventh leaf of every fourth plant down the centre of the plots, totalling twenty plants in each plot.

TABLE I
A.I.B.G.A. LEAF SPOT ESTATE BORDEAUX TRIALS (1955)

Mean % Area Of 7th Leaf Spotted			
Estate Mean	3-Leaf	Comprehensive	Ordinary (Control)
3.7	0.9	2.0	8.3
4.0	3.5	3.8	4.6
4.1	3.6	4.8	3.8
5.2	2.6	8.0	5.0
5.3	7.3	3.8	4.7
6.2	5.0	4.7	8.9
6.6	7.4	4.2	8.3
6.9	3.8	7.6	9.3
6.9	8.0	7.6	5.0
7.3	5.7	7.9	8.4
8.2	5.6	5.2	13.7
8.8	9.3	8.4	8.6
11.2	12.3	5.3	15.9
13.9	13.8	10.1	17.1
16.3	14.6	19.0	15.2
17.6	16.6	8.5	27.8
23.7	16.5	26.2	28.5
Mean	8.02	8.06	11.39

Significant difference ($P = 0.01$)
between means

Spraying treatment	3.27
Estates	7.81

October is not late enough in the year to judge the full effect of any spray treatment, especially as most of the experimental spraying in these trials did not start until June. Results, however, were so striking in that month, as shown in Table I, that the A.I.B.G.A. decided to arrange for shipments of Triton X-114 so that it could be supplied with all allocations of Bordeaux material to growers early in 1956.

The use of Triton X-114 Bordeaux mixture has improved the standard of Leaf Spot control tremendously throughout Jamaica, provided that growers supervise the application of spray onto the underside of the youngest leaves. Although most growers have persisted with comprehensive spraying of all foliage, there has been a tendency towards reducing the number of gallons sprayed per acre. One attribute of Triton X-114 has been its ability to aid in the supervision of spraying work because the spray deposit is clearly visible from the ground on the surface of the highly waxed undersurface of the youngest leaves.

B. Oil Spraying Trials For Control Of Leaf Spot

The Plant Pathologist attended a tour in Guadeloupe arranged by the Caribbean Commission to see the work of the Institut des Fruits et Agrumes Coloniaux (I.F.A.C.) in the control of banana leaf spot by a method of mist-spraying, with copper oxychloride (or Zineb) suspended in Orchard Spray Oil, which was developed there. A Report on "Banana spraying tour in Guadeloupe arranged by the Caribbean Commission" was submitted to the Banana Board in conjunction with delegates from the A.I.B.G.A.

As a result of the successful control observed, by the oil spraying in Guadeloupe, experimental trials were immediately started in Jamaica after the tour. In the first instance mist-spraying with oil from a knapsack machine was carried out on a 5 acre plot of bananas at Monymusk estate, West Indies Sugar Company, using the same oil/copper mixture as that being

used on estates in Guadeloupe. This test lasted for 3 months in order to obtain bunches which had been sprayed regularly every three weeks with copper in oil from the time of shooting to that of reaping. The oil spray mixture used was:

Esso Orchard Spray Oil	— 4.5 gallons	} at the rate of 2½ gallons per acre
Diesel oil	— 1.1 gallons	
Copper oxychloride	— 6.6 lbs.	

At the end of three months, bunches which had been sprayed with the above oil mixture were shipped to the United Kingdom for analysis by the Port of London Health Authorities from whom the following report was received:

"I am pleased to inform you that the copper content found appears to be negligible when compared with the general limit of copper in foodstuffs recommended by the Food Standards Committee of the Ministry of Agriculture, Fisheries and Food.

It would appear, therefore, that provided, as stated in a letter dated 8th March, 1956, from Mr. Leach, Director of Research, Banana Board, Kingston, Jamaica, that the composition of the spray, applied at the low-volume rate of 2½ gallons per acre and consisting of:—

4.5 gallons of Esso Orchard Spray Oil
1.1 gallons of Diesel oil and
6.6 lbs. of Copper oxychloride

is not exceeded, there would be no grounds, from a public health point of view, for prohibiting the importation of bananas so treated, into the United Kingdom."

After receiving this satisfactory report, further trials with oil spraying were instituted throughout the island.

(i) **All-island oil spraying trials:** Five different spray mixtures were tested on each of the following estates: Hampden, Trelawny; Haughton Hall, Hanover; Egypt Pen, St. Mary; Duckenfield, St. Thomas; Monymusk, Clarendon. The Research Department was fortunate in obtaining the services of S. G. Evans, Plant Pathologist of Plant Protection Ltd. (Messrs. T. Geddes Grant Ltd., Kingston, Jamaica) to undertake these trials. Due to his untiring efforts in travelling continuously round Jamaica, laying out and conducting the trials, valuable experience was gained in connection with the whole procedure of oil spraying with mechanical knapsack mist-spraying machines on level and hillside lands. The main object of these trials was to test different spray mixtures at the following rates per acre:

- | | |
|---|-----------------|
| I. Oil A | — 13 pints |
| Diesel oil | — 3 pints |
| Copper oxychloride | — 3 lbs. |
| II. Oil A | — 2 gallons |
| Cuprous oxide in oil | — 11 fluid ozs. |
| III. Spray oil A alone | — 2 gallons |
| IV. Cuprous oxide | — 4 lbs. |
| (Perenox) | |
| Agral | — 36 ccs. |
| Water | — 4 gallons |
| V. Bordeaux mixture 8:10:100 + Triton X-114 (estate sprayed as a control) | |

These treatments were applied on all five estates, each treatment plot being at least one acre in extent. No unsprayed control plots were included because growers were not anxious to have such plots in plantations where they wished to maintain good leaf spot control. The Bordeaux sprayed areas acted as controls for the purposes of these trials, this being the accepted form of spraying throughout the island although the standard of control obtained by it varied directly with the thoroughness of the application as was shown in the AIBGA Bordeaux-Triton Spraying Trials. The results of S. G. Evans' estate trials are summarised in Tables II and III, extracted from his Report, submitted to the Banana Board, entitled "Control of banana leaf spot — Reports on trials with oil and other fungicides in Jamaica: 1956/57".

TABLE II
ALL-ISLAND OIL SPRAYING TRIALS

(a) Mean % area of 5th to 8th youngest leaves affected by leaf spot

	Spray Treatment				
	I	II	III	IV	V
	Spray oil A, diesel oil, copper oxychloride	Spray oil A cuprous oxide	Spray oil A only	Cuprous oxide + Agral LN in water	Bordeaux 8:10:100
St. Thomas	7.2	5.6	11.0	14.0	8.0
Trelawny	3.8	3.1	5.0	17.1	9.6
St. Mary	0.2	0.1	0.3	0.9	1.9

(b) Mean % area individual leaves affected by leaf spot.

Leaf No.	I	II	III	IV	V
5	1.5	1.2	2.0	4.1	3.0
6	3.4	2.6	5.3	9.0	5.5
7	4.2	3.0	7.6	12.0	7.9
8	5.8	5.0	7.4	18.9	14.1

TABLE III
ALL-ISLAND OIL SPRAYING TRIALS

A. Total damage — % area 5th to 8th youngest leaves affected.

Spray Treatment	Leaf No.				ESTATES
	5th	6th	7th	8th	
Spray oil A + diesel oil + copper oxychloride	12.1	26.4	37.1	64.0	Hanover & Hampden (A)
Spray oil A + cuprous oxide	9.6	16.1	24.8	36.4	Hanover, Hampden (A & B)
Spray oil A only	10.6	16.8	21.9	36.4	Hanover, Hampden (A & B)

B. Leaf spot — % area 5th to 8th youngest leaves affected.

Spray Treatment	Leaf No.				ESTATES
	5th	6th	7th	8th	
Spray oil A + diesel oil + copper oxychloride	9.6	16.9	25.1	26.3	Hanover & Hampden (A)
Spray oil A + cuprous oxide	6.8	11.5	13.2	18.4	Hanover, Hampden (A&B)
Spray oil A only	7.8	13.3	15.4	24.1	Hanover, Hampden (A&B)

C. Phytotoxicity — % area 5th to 8th leaves scorched.

Spray Treatment	Leaf No.				ESTATES
	5th	6th	7th	8th	
Spray oil A + diesel oil + copper oxychloride	2.5	9.5	12.0	37.7	Hanover, Hampden (A)
Spray oil A + cuprous oxide	2.8	4.6	11.6	18.0	Hanover, Hampden (A&B)
Spray oil A only	2.6	3.5	6.5	12.3	Hanover, Hampden (A&B)

The figures represent clearly the trend in the difference between the different treatments although no actual significant difference was obtainable from them, due to the high degree of variability in the amount of leaf spot in the different trial areas. The main issues emanating from these trials were:—

- (a) the satisfactory control of leaf spot obtained by the use of Orchard Spray Oil alone.
- (b) the inclusion of copper in the oil was of no material benefit and only enhanced the amount of scorching associated with the spraying of foliage too close to the nozzle of the mist-blower.
- (c) the need for care in avoiding direct spraying of the bunches because severe scorching of a bunch results in a reddish-brown discoloration of the skin of the green banana and this turns black during ripening.
- (d) under drought conditions scorching of the foliage is greater in the open than under the shade of other trees.

(ii) **Estate spraying trials:** These were carried out on approximately 80 acres on each of four of the estates where S. G. Evans conducted his trials, the estate management being responsible for the spraying. They were by no means as successful as the experimental plot trials; in fact on two of them there was a particularly bad breakdown in control by the end of the trials (February 1957). These breakdowns, however, could be explained, for the most part, by inaccurate spray application. In one case this was aided also by the very thick canopy of banana foliage. On the other estates the standard of control was excellent. These estate trials were definitely useful in demonstrating the various sources of danger to bananas being mist-sprayed with oil.

(iii) **500 acre estate spraying trial:** This trial, at Monymusk, showed how efficiently oil spraying can be organised by good estate management. Eight men with five mechanical knapsack machines sprayed at the rate of 100 acres a day and maintained a high standard of control although, admittedly, the incidence of leaf spot was generally low in that area.

(iv) **Land-Rover team spraying project:** The spray unit team did not start until too late in the year for any results to be reported here.

(v) **Temple Hall Estate trial:** This was started by S. G. Evans on September 4th when bananas were showing evidence of an impending serious increase of spotting, appreciable spotting being visible on many of the third youngest open leaves — a sure sign that heavy infection had occurred on those leaves at the time that they opened. This experiment, also, demonstrated that oil alone is as effective as oil + copper in checking a severe attack of leaf spot quickly.

In this experiment the disease was so severe at the start that it was decided to apply 3 gallons of oil per acre. The schedule for the duration of the trial was —

Sept. 2nd, 16th, 30th, Oct. 16th	— 3 gallons per acre
Oct. 27th	— 2 gallons per acre
Nov. 11th	— 1½ gallons per acre
Nov. 24th, Dec. 7th, 20th,	
Jan. 3rd, 16th, Feb. 4th	— 1 gallon per acre

For each treatment the tank was filled with 2 gallons of one of the following:—

1. Spray oil A, 13 pints; + diesel oil, 3 pints; + 3 lb. copper oxychloride.
2. Spray oil A, 2 gal.; + cuprous oxide in oil 11 fl. oz. containing $\frac{3}{4}$ lb. copper (i).
3. Spray oil A, 2 gal.; + cuprous oxide in oil, 11 fl. oz. containing $\frac{3}{4}$ lb. copper (ii).
- 4, 5. Spray oil A alone.
- 6, 7. Spray oil B alone.

The results of the experiment extracted from S. G. Evans' Report are given in Table IV.

TABLE IV
TEMPLE HALL OIL SPRAYING TRIAL
 % area six youngest leaves affected by leaf spot.

Spray Treatment	Date Recorded						
	Sep. 6	Sep. 18	Sep. 25	Oct. 19	Nov. 13	Jan. 25	Feb. 24
Spray oil A + diesel oil + copper oxychloride	24.9	16.7	10.7	4.3	1.3	2.7	2.9
Spray oil A + cuprous oxide (i)	28.0	22.7	13.3	6.3	1.9	3.2	3.9
Spray oil A + cuprous oxide (ii)	12.8	10.1	6.7	4.3	0.3	3.6	2.7
Spray oil A only (i)	14.7	8.4	6.3	0.9	0.1	2.7	2.9
Spray oil A only (ii)	11.5	9.3	5.6	2.3	0.3	3.1	3.6
Spray oil B only (i)	23.5	18.2	13.5	5.3	2.0	3.9	3.7
Spray oil B only (ii)	21.4	13.7	8.3	2.1	0.5	2.8	3.2
Control (unsprayed)	—	—	—	—	—	28.6	29.9

Apart from S. G. Evans' records, the development of the disease on the individual leaves of every fourth plant in every fourth row was recorded throughout the trial. The youngest leaf on each recorded plant was marked on the day of the first spraying so that the subsequent spot development could be followed in detail on leaves of different ages. The figures in Table V show how slowly the spotting increased on the leaves which were the third youngest on the plants at the time that spraying commenced on September 4th. The fungistatic effect of the oil on the fungus, already established in the leaf tissues, is well demonstrated because if no oil had been used the rate of spot development would probably have been similar to that of the unsprayed plot in the helicopter trials, (see Table VII), which was equally heavily infected. As there was no difference between the various treatments used at Temple Hall the means shown in Table V were obtained from several individual leaves irrespective of treatment.

TABLE V
TEMPLE HALL OIL SPRAYING EXPERIMENT
 Rate of Spot Development On 3rd & 4th Youngest Leaves
 (Variously spotted at commencement of oil spraying, Sept. 4, 1956)

ORIGINAL % AREA SPOTTED	ORIGINAL LEAF NO.	Mean % Area Leaf Spotted						Increase
		Sept. 4th	Sept. 11th	Sept. 18th	Sept. 25th	Oct. 5th	Nov. 17th	
0	3rd 4th	0.0 —	2.5 —	4.7 —	6.2 —	7.1 —	9.2 —	+ 9.2
3	3rd 4th	3.0 3.0	5.8 8.5	10.8 11.0	12.8 11.0	15.0 12.5	23.7 14.0	+ 20.7 + 11.0
6	3rd 4th	6.0 6.0	17.3 14.7	19.0 18.7	21.0 18.7	23.0 27.3	26.0 36.3	+ 20.2 + 30.3
9	3rd 4th	9.0 9.0	16.0 11.8	19.0 15.9	22.0 22.8	30.2 30.2	34.2 30.2	+ 25.2 + 21.2
13	3rd 4th	13.0 13.0	21.7 19.0	25.0 19.0	26.3 20.0	27.0 27.0	34.0 34.0	+ 21.0 + 21.0
19	3rd 4th	19.0 19.0	27.0 27.8	37.3 29.0	38.9 35.0	41.3 43.0	42.7 55.4	+ 23.7 + 26.4
25	3rd 4th	25.0 25.0	40.5 31.1	43.5 38.2	46.5 44.8	49.3 47.3	49.3 64.7	+ 24.3 + 39.7

(Note: No fourth leaves were free of leaf spot)

In this Table the third and fourth youngest open leaves at the commencement of spraying are subdivided into categories according to the amount of spotting seen on them at that time. These categories are represented as the original percentage area spotted.

(vi) **Helicopter versus mechanical knapsack oil spraying trial:** Results of this trial were highly satisfactory in that the helicopter obtained almost as good control of leaf spot as the knapsack mist-sprayer in a plantation very heavily leaf spotted. The helicopter spraying was over an area of 5 acres as also was that of the knapsack spraying. Fortunately the estate allowed half an acre of bananas to be left unsprayed as a control plot nearby, on the other side of a river. The amount of spotting was recorded on every fourth plant in every fourth row of each sprayed plot but in the small control plot every third plant in every other row was recorded in order to provide an adequate number of plants from which to assess disease behaviour. The recording procedure was the same as that at Temple Hall.

Records of disease intensity were only taken on the six youngest leaves at the start of the experiment because the disease was so severe that many of the seventh leaves were hanging dead. After a period of only 2 months when the effects of the spraying treatments were finally recorded, almost complete control had been achieved on the first six leaves. The results of the experiment are given in Table VI.

TABLE VI
HELICOPTER OIL SPRAYING EXPERIMENT
(Sprayed Oct. 11th, Oct. 25th, Nov. 8th, Nov. 22nd)
A. Average % area of each leaf killed by leaf spot

Leaf No.	Control (½ acre)		Helicopter (5 acres)		Mechanical Knapsack Mist-sprayer (5 acres)	
	Start Oct. 11	End Dec. 16	Start Oct. 11	End Dec. 16	Start Oct. 11	End Dec. 16
1st	0.0	0.0	0.0	0.0	0.0	0.0
2nd	0.0	0.0	0.0	0.0	0.0	0.0
3rd	2.8	3.1	5.4	2.0	4.6	1.5
4th	16.5	22.2	40.3	5.1	24.6	6.0
5th	46.0	37.8	64.1	3.8	42.3	4.3
6th	63.8	57.7	82.9	9.8	58.9	5.0

B. Average % area of first six leaves killed by leaf spot

		Row									
		1	2	3	4	5	6	7	8	9	10
CONTROL	11/10/56	17.3	20.9	25.8	22.0	—	—	—	—	—	—
	16/12/56	19.3	23.9	19.0	18.4	—	—	—	—	—	—
HELICOPTER	11/10/56	21.2	34.1	34.2	43.0	38.7	34.7	29.7	28.4	26.8	30.6
	16/12/56	4.1	4.4	4.1	4.5	4.9	5.8	3.8	2.8	2.6	3.5
KNAPSACK MIST-BLOWER	11/10/56	16.9	17.6	22.8	24.6	25.4	18.7	25.1	23.0	—	—
	16/12/56	3.4	4.7	3.1	2.4	2.6	2.7	2.4	1.7	—	—

By examining the records of spot development in detail on individual leaves the fungistatic effect of oil was clearly shown by the comparative figures shown in Table VII in which the originally recorded leaves have been grouped according to the amount of spotting on them at the start of the spraying on October 12th, again on November 1st and finally on December 16th.

TABLE VII

**RATE OF SPOT DEVELOPMENT ON LEAVES DIFFERENTLY INFECTED BEFORE
SPRAYING WITH OIL**

Mean % area of leaf spotted

No. of leaves recorded (A)	(B)	SPRAYING TREATMENT	(A) 3rd youngest open leaf			(B) 2nd youngest open leaf		
			Oct. 10th	Nov. 1st	Dec. 16th	Oct. 10th	Nov. 1st	Dec. 16th
9	2	NONE (CONTROL)	0.0	9.0	71.7	0	0.0	13.0
11	4		3.0	26.0	98.7	0	3.0	17.5
3	13		6.0	37.0	100.0	0	6.0	46.5
1	8		9.0	37.0	100.0	0	9.0	53.5
0	4		—	—	—	0	13.0	71.5
3	23	HELICOPTER	0.0	13.0	23.0	0	0.0	5.3
38	23		3.0	17.9	47.4	0	3.0	8.7
12	5		6.0	18.4	40.2	0	6.0	12.0
5	8		9.0	26.6	60.3	0	9.0	17.3
2	3		13.0	16.0	22.0	0	13.0	17.0
14	27	KNAPSACK	0.0	6.1	13.2	0	0.0	5.5
26	21		3.0	6.9	18.8	0	3.0	8.7
6	5		6.0	13.0	32.2	0	6.0	8.8
2	3		9.0	19.0	37.0	0	9.0	15.7
6	2		13.0	16.0	23.0	0	13.0	16.0

The difference between the sprayed and unsprayed plants is very marked. The spotting was much heavier in the helicopter sprayed plot at the start of the experiment so that there would have been a tendency for infection to have been heavier there at that time. Reference to Table VII shows that in the unsprayed plots the rate of spot development was so rapid that the lightly spotted third leaves were nearly all dead within 2 months.

The helicopter spraying was as effective as the knapsack spraying on all except the 3rd youngest leaves open at the start of the experiment. This can only have been due to the spray from the helicopter failing to attain an adequate deposit of oil on the undersides of these more horizontally orientated leaves. The fungistatic effect in the helicopter spraying on the two youngest leaves was, however, good and resulted in control by the helicopter being as effective in general as that obtained with the knapsack sprayer. A decrease in the droplet size from the helicopter would obtain a still higher standard of control due to turbulence distributing more droplets onto the under surface of all leaves. Incidentally, this experiment provided a severe test for the helicopter because the mass of heavy spotting on the living and dead foliage provided a very high inoculum potential within the plantation. An even higher standard of leaf spot control should be readily maintained by helicopter spraying in new plantations when spraying is started before any leaf spot appears.

(vii) **Oil spraying of bananas in coconut plantations:** As many bananas are grown in coconut plantations in Jamaica, an experiment was designed to test the possibility that oil spraying against leaf spot might be injurious to the coconut crop. While S. G. Evans was carrying out his banana spraying trials in St. Thomas, he conducted a small trial on young bearing coconuts at Clifton Hill Estate for the Research Department. Spraying was done on three separate occasions at approximately 3-weekly intervals, using 2½ gallons of oil per acre. The youngest spadix open at the time of each spraying was marked so that the effect on the flowers and young fruits could be accurately assessed by the time all natural nutfall had ended i.e. after a period of four months. No ill-effects on the setting of the fruit nor on nut development were noted. The oil, in fact, had no effect on the production of fruit on two spadices which were sprayed at the time when their female flowers had just opened for the stigmas to be receptive for pollination.

C. Diseases Of Shipped Fruit

Before sailing to take up his appointment, the Plant Pathologist visited Avonmouth and London Docks to examine the condition of bananas reaching the U.K. from Jamaica because much of the fruit was reported to be heavily diseased. As this was found to be so, investigations on this problem were started by the Research Department at the earliest opportunity. Unfortunately, owing to the absence of laboratory and cool storage facilities in Jamaica, these could only be undertaken by dispatching tagged fruit to the United Kingdom. The assistance given by the United Fruit Company and the Jamaica Banana Producers Association Ltd. in Jamaica is gratefully acknowledged here as also is that given by all those members of Messrs. Elders & Fyffes Ltd., and Messrs. Jamaica Producers Marketing Company Ltd., who provided detailed reports on the condition of the fruit after arrival in the U.K. Without all this co-operation the investigations could of course never have been undertaken. Twenty-six shipments consisting of 163 different consignments of fruit were sent to the U.K. between October 1955 and July 1956.

The four main diseases reported upon in the U.K. were:

(a) **Scarring:** Any superficial dry blemish turning the skin black without causing active rotting.

(b) **Soft stem end rot:** (Wardlaw⁽³⁾, Main-stalk rot): A rot that starts in the fruit stalk and passes into the cushion of a hand and thence into the finger stalk causing the fingers to drop.

(c) **Santa Marta stem end rot** (Wardlaw, Finger stalk rot): *Gloeosporium musarum* and/or *Thielaviopsis paradoxa* enter at bruised lesions on the finger stalk caused by severe bending and squeezing of the tissues; this disease is the main cause of loose fingers arriving in the U.K.

(d) **Anthraxnose** (Wardlaw, *Gloeosporium* fruit rot): *Gloeosporium* infects the skin and develops noticeably towards the end of the voyage and in the ripening rooms to form a black, sunken scar which gradually enlarges, having its surface covered with the pink encrustations of the fungus spores and being surrounded by a yellowish-orange halo in the skin.

Experimental shipments of fruit handled in different ways on the trucks and in the wash boxes were sent to the U.K. wrapped in the usual polythene bags and tied with coloured tapes to distinguish the different handling treatments. In some cases differently treated truck loads were compared but in most shipments the different treatments were randomised by subdivision on several individual trucks, different truck loads providing the required replications.

An Index No. for each disease was obtained from Messrs. Elders & Fyffes for each consignment of tagged fruit in each shipment of experimental fruit. The Index No. was calculated from the percentage of bunches falling into the following categories:

Category Value

(N) Negligible	..	0
(T) Trace	..	1
(S) Slight	..	2
(M) Moderate	..	3
(H) Heavy	..	4

$$\text{"Index No."} = \% \frac{\text{No. stems in each category} \times \text{Category Value}}{4}$$

4

$$\text{For instance: } \begin{array}{ccccc} \text{N} & \text{T} & \text{S} & \text{M} & \text{H} \\ \hline 50 & 19 & 22 & 8 & 1 \end{array} = \text{Index No. 22.75}$$

When these investigations started, anthracnose was thought by some people in the industry to be caused by acid burn, consequent upon the fruit being imperfectly washed after the removal of Bordeaux mixture in the acid washing tank (sodium bisulphate). The first shipments soon proved this hypothesis to be untenable since the disease developed in unsprayed and unwashed fruit, as shown in Table VIII. All fruit in this shipment came from one truck load of bananas. The wetting of the fruit by washing in water alone, prior to bageing in polythene tubing, appeared to increase the disease considerably but there was an insignificant, additional detrimental effect caused by washing in the acid bath as well.

TABLE VIII
DIFFERENT WASHING METHODS

v. Shipment 12.12.55.

No. of bunches	TREATMENT	INDEX NO.			
		Scarring	Anthracnose	Soft Stem End Rot	Santa Marta Stem End Rot
67	Unwashed	47.5	58.5	58.5	53.5
46	Washed in water only	45.0	85.0	61.5	63.0
80	Washed in acid bath and water	54.0	90.8	71.8	63.0

In further tests for acid burn, the fruit was washed in limed water in which 10 lbs. lime was added to 400 gallons water in the wash tank, with further lime being added whenever the water approached neutrality. This was done either before the final washing with fresh water or, in some cases, after the fresh water wash. In the latter case a faint inconspicuous deposit of lime was left on the skin. In no case was there any evidence of less acid burn due to these different lime washing treatments. As a result of these experiments the name "Anthracnose" has replaced acid burn, because the symptoms corresponded to those of a similar disease described by Wardlaw and also in Australian Journals.

Attention was then drawn to examining the effect of the rough handling to which fruit is subjected prior to shipment. An attempt was made to correlate the amount of damage seen on the fruit at Bowden wharf with the subsequent detailed reports on the incidence of the diseases noted on its arrival and in the ripening rooms in U.K. especially in regard to anthracnose.

An experiment was carried out to compare the effect of packing the fruit on trucks using (1) cut-up pseudostems of the Lacatan banana and (2) trash between each layer ("flats") of fruit. The use of sheaths had been advocated as they are used successfully in Central American countries where Gros Michel bananas are grown extensively. The Lacatan sheaths are much smaller than those of Gros Michel and it is impossible to place one bunch on to one portion of a cut sheath with the result that the edges of the various Lacatan sheaths rub and bruise the fruit severely. This was evident on inspection of the fruit on arrival at Bowden wharf. The ill effect of using sheaths was clearly demonstrated at the start of these shipping experiments as shown in Table IX.

TABLE IX
DIFFERENT METHODS OF PACKING FRUIT ON TRUCKS

- (a) Trash between "flats"
(b) Sheath (cut portions of pseudostems) between "flats"

INDEX NO.

SHIPMENT	Scarring		Anthracnose		Soft Stem End Rot		Santa Marta Stem End Rot	
	Trash	Sheaths	Trash	Sheaths	Trash	Sheaths	Trash	Sheaths
28/12/55	No	report	54	76	56	79	39	55
3/ 1/56	29	33	33	44	33	40	22	26
9/ 1/56	38	46	48	61	31	43	38	40

The use of blankets for wrapping the fruit in the manner used on the trucks in Guadeloupe was tried as it was hoped that this method would reduce anthracnose considerably, especially when it was noticed that the fruit wrapped in blankets arrived at the wharf remarkably free of obvious bruising. The experiment with blankets, however, gave disappointing results as the difference between wrapping in trash and wrapping in blankets was not as great as it had been hoped.

TABLE X

DIFFERENT METHODS OF WRAPPING FRUIT IN TRUCKS

(Trash v Blankets)

INDEX NO.

SHIP- MENT	TRUCK No.	Scarring		Anthracnose		Soft Stem End Rot		Santa Marta Stem End Rot	
		Trash	Blanket	Trash	Blanket	Trash	Blanket	Trash	Blanket
6/2/56	1.	55	36	64	40	53	48	54	41
	2.	35	36	35	36	46	48	45	52
	3.	20	24	20	23	33	38	23	33
13/2/56	1.	29	24	31	24	21	16	18	26
	2.	40	29	15	15	28	25	38	40
	3.	25	18	11	10	28	15	20	21
	4.	30	25	17	3	23	23	25	21
20/2/56	1.	33	29	52	41	38	42	33	34
	2.	16	18	22	11	33	37	16	18
26/3/56	1.	36	24	28	22	24	23	30	25
	2.	27	17	16	14	31	25	26	25
	3.	25	21	27	18	24	23	21	24
Mean		30.9	25.1	28.2	21.4	31.8	30.3	29.1	30.0

In most shipments there was a distinct correlation between the amount of damage noticed on the fruit at the wharf and the amount of disease reported from the U.K. There were, however, two striking cases where fruit was dispatched practically free of obvious bruises on the day of shipment but which developed anthracnose more severely than any other consignments sent to the U.K. These two cases occurred on fruit which was wrapped in almost dry trash and which was then packed carefully but not tightly in the trucks. The report received on one of these was described as "quite the worst ever handled from Jamaica".

The conclusion reached as a result of these two cases was that slight abrasions of the skin are more conducive to the development of anthracnose than visible severe bruising. The usually close correlation between the amount of damage seen on the fruit and the reports received from the U.K. would seem, however, to indicate that whenever badly bruised fruit is seen on the wharf it is likely that the fruit is also severely, although inconspicuously, abraded.

One of the features of the reports received from the U.K. was the frequent correlation between the amounts of the four different diseases recorded in each shipment. It is known that Santa Marta stem end rot is caused by bending and squeezing of the finger stalks caused by rough handling. The Index Numbers for anthracnose, received in the various individual shipments reports, was significantly correlated with those for Santa Marta stem end rot and scarring. This would seem to show that these diseases are encouraged by a common factor, rough handling, although they are not always due to infection by the same organism.

The amount of damage done to fruit during truckage was clearly demonstrated in an experiment in which individual bunches were numbered on the field stand just before being lifted on to a road haulage truck. The two top hands and the bottom (butt-end) hands were examined for the presence of squeezed fingers on each bunch. As the fruit on the truck was being unloaded into the wash tanks, approximately every fifth bunch was put on one side for subsequent examination of damage to fingers. The damage caused to finger stalks by being bent and having their tissues squeezed was considerably increased during the journey from the field to the wharf, as shown in Table XI.

TABLE XI
DAMAGE DURING TRUCKAGE

vii. Shipment 28.12.55

Total No. Bunches = 34	No. Finger stalks damaged (squeezed)				% Bunches affected	
	Hand	Top	2nd	Butt-end	Total	
Before trucking		4	0	4	8	20.6
After trucking		23	10	41	74	88.2

In another experiment, from one truckload of bananas wrapped in dry trash, twenty-nine bunches were kept back on the wharf after being passed through the wash boxes, where they appeared remarkably free of bruises. After being kept for two days covered on the wharf, surface bruising was clearly visible on many fingers and the considerable extent of damage seen on these bunches is shown in Table XII. The remainder of the fruit in this truckload was subjected to a handling test in the wash boxes; it arrived in the U.K. heavily diseased having the very high, mean anthracnose Index No. of 87.5.

TABLE XII

vi. Shipment 21.12.55

29 Bunches examined 23.12.55

Position of hand	No. Hands	% Hands with finger stalks squeezed	% of Fingers with squeezed stalks	% Fingers with surface bruises	
				Outer Finger	Inner Finger
Top	29	59	7.0	8.4	2.3
2nd	29	38	4.3	12.4	2.3
3rd	29	24	2.0	26.5	5.7
4th	29	28	2.2	23.0	2.7
5th	29	34	3.7	27.0	2.8
6th	23	33	5.8	28.1	4.5
7th	5	40	3.8	22.2	2.9
8th	1	—	—	20.0	—
Butt-end or 9th	29	82	17.7	23.9	2.6
MEAN		42.3	5.8	23.9	3.2

(Note: 23 six-hand, 5 seven-hand and one eight-hand bunch)

The effect of the height of packing bunches on trucks was tested. Table XIII shows that seven (7) flats proved better than nine (9) or five (5). When the trucks are packed too high, there is the effect of pressure on the lower bunches but what is probably more important is the damage caused in loading and unloading the fruit on and off the trucks. When the trucks are packed with too little fruit in them, there is danger of the fruit moving during transport and consequently it is more likely to be rubbed and abraded.

TABLE XIII
HEIGHT OF PACKING FRUIT ON TRUCKS
(No. of "flats")

INDEX NO.

ESTATE	Scarring			Anthracnose			Soft Stem End Rot			Santa Marta Stem End Rot		
	9.	7.	5.	9.	7.	5.	9.	7.	5.	9.	7.	5.
No. of flats	29	28	34	33	22	31	35	35	32	25	25	29
3.	32	25	36	36	31	42	39	34	43	33	29	30
2.	21	23	25	19	19	23	35	35	34	25	19	26

TABLE X
DIFFERENT METHODS OF WRAPPING FRUIT IN TRUCKS

(Trash v Blankets)

INDEX NO.

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	3.	20	24	20	23	33	38	23	33
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	2.	16	18	22	11	33	37	16	18
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3.	32	25	36	36	31	42	39	34	43	33	29	30
2.	21	23	25	19	19	23	35	35	34	25	19	26

As a result of these experimental shipments, recommendations were made to the Banana Board that efforts should be made to reduce the amount of damage caused by rough handling of fruit. Unfortunately little progress was made in this direction and by October 1956 serious reports were received from the United Kingdom about the condition of Jamaican bananas especially in regard to the incidence of anthracnose.

A shipment of fruit was then kept under close observation throughout a voyage to the U.K. on S.S. "Corrales" which left Jamaica on November 7th. During the voyage various types of blemish were noted on individual fingers and the development of anthracnose was studied in all its stages. A full report of the investigations made on this voyage was submitted to the Banana Board entitled "An investigation into the development of banana diseases during transport overseas and in the U.K. ripening rooms". Anthracnose only developed on abrasions which could just be seen with the naked eye two or three days after the fruit had been put on board. The main conclusion reached from the tagged fruit experiments from Bowden was therefore fully substantiated by the evidence collected on the S.S. "Corrales".

In the absence of any laboratory facilities these somewhat crude investigations were the only method of investigating the development and behaviour of diseases on fruit shipped to the U.K. Once laboratory facilities are available, investigations will be possible in far greater detail. The inclusion of cooling and ripening rooms attached to the laboratory will facilitate investigations into ways and means of overcoming the problem of diseases developing on fruit transported overseas.

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